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VIEWPOINT

Optimal Treatment of Patients Surviving Out-of-Hospital Cardiac Arrest

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Interest in post-resuscitation care has risen with the development of treatment modalities that can affect long-term survival rates even when begun after the systematic ischemia/reperfusion insult associated with cardiac arrest. Mild therapeutic hypothermia has become the foundation for improvement of neurologically favorable survival after cardiac arrest. Reperfusion therapy, specifically early percutaneous coronary intervention, is becoming an important adjunct to therapeutic hypothermia. Identifying which post–cardiac arrest patient had an occluded or unstable coronary vessel is difficult because such events are not reliably predicted by precedent symptoms or standard electrocardiographic analysis. Increasing clinical experience suggests that resuscitated cardiac arrest victims without an obvious noncardiac etiology should undergo emergency coronary angiography and, where indicated, percutaneous coronary intervention. If comatose, they should receive concurrent therapeutic hypothermia. Such an approach can double long-term survival rates among those successfully resuscitated after out-of-hospital cardiac arrest. (J Am Coll Cardiol Intv 2012;5:597–605) © 2012 by the American College of Cardiology Foundation

Long-term outcomes after out-of-hospital cardiac arrest (OHCA) remain dismal, with a 5% to 10% survival rate (1). Even among those fortunate enough to be initially resuscitated, only about 25% survive the subsequent hospitalization (2–6). Of a theoretical 100 patients suffering OHCA, approximately 40 will be successfully resuscitated with restoration of spontaneous circulation. Sixty percent die in the field without a restoration of pulse or blood pressure. Among the 40 patients admitted to the hospital, only 10 will survive to hospital discharge. Seventy-five percent die during their hospitalization (Fig. 1).

The leading causes of death after resuscitation are central nervous system injury and myocardial failure (7). Investigators in Norway have shown that by formalizing a more aggressive approach to post-resuscitation care, long-term survival can be improved. Noting a historical post-resuscitation survival rate of only 26% in their university hospital, they instituted a standardized post-resuscitation care program that mandated the use of mild (32°C to 34°C) therapeutic hypothermia and early cardiac catheterization with percutaneous coronary intervention (PCI) for appropriate lesions (8). After several years of this new standard operating procedure for post–cardiac arrest care, their 1-year survival rate, for those initially resuscitated and admitted to the hospital, increased to 56%. Most importantly, >90% of those who survived had a cerebral performance category score of 1, signifying normal, intact neurological function. They have continued to see similarly high rates of neurologically favorable survival since instituting such changes in 2003. These investigators recently published their expanded experience from 2003 to 2009, reporting on 248 post-resuscitation patients with a presumed cardiac cause for their arrests (9). Survival-to–hospital discharge was 61% of those initially resuscitated, with 93% of all survivors having favorable neurological function at discharge. Many of

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the 7% with less-favorable neurological function typically died within the first year after arrest, and nearly all within 2 years (10). The common fear that aggressive post-resuscitation therapy will result in our chronic care facilities being filled to overflowing with those neurologically incapacitated after cardiac arrest is simply unfounded. The final analysis showed that 1-year survival was 56%, with 95% of all survivors exhibiting excellent neurological function (Fig. 2).

Post-Resuscitation Care That Improves Outcome

Mild therapeutic hypothermia (MTH) after cardiac arrest. MTH involves cooling to a core temperature of 32°C to 34°C for 12 to 24 h before a slow rewarming (0.3°C/h to 0.5°C/h) period. Complications after such treatment are rare, whereas the advantages are substantial. Two randomized clinical studies in out-of-hospital ventricular fibrillation cardiac arrest found that cooling increased patients' survival rates and survival with good neurological function, compared with the rates for patients who were not cooled (11,12) (Table 1).

Induced hypothermia for patients remaining unresponsive or comatose after resuscitation is the first clinically effective treatment of the major ischemic and reperfusion central nervous system injuries associated with cardiac arrest. In 2003, the American Heart Association and the International Liaison Committee for Resuscitation published a joint statement supporting the use of MTH in all comatose survivors of out-of-hospital ventricular fibrillation cardiac arrest (VFCA) (13). This original statement emphasized such treatment for those suffering VFCA, because that was the population studied in the randomized trials. They speculated that hypothermia could be beneficial for non-VFCA patients as well. Subsequently, further nonrandomized clinical experience suggests that those suffering non-VFCA also benefit, though their overall outcomes are not as good as those with VFCA (14). The 6-month survival rates for those with witnessed non-VFCA was 25% if not cooled and 39% if cooled ($p = 0.025$), whereas favorable neurological outcome in those who survived was excellent in both groups (93% vs. 89%, $p = 0.5$).

An important caveat learned with the increased use of hypothermia after arrest is that at least 72 h is required after rewarming before accurate neurological prognostication can be made. Hypothermia is neuroprotective and seems to alter the central nervous system injury, but it also alters the evolution of neurological recovery compared with neurological recovery in normothermic patients. The International Liaison Committee on Resuscitation in their consensus statement titled "Post Cardiac Arrest Syndrome: Epidemiology, Pathophysiology, Treatment, and Prognostication" noted "prognostication strategies established in patients who were not treated with hypothermia might not accurately predict the outcome of those treated with hypothermia (15, p. 2469)." Hypothermia may distort the neurological examination through delaying the clearance of sedatives or neuromuscular-blocking drugs (15). Significant thought and discussion should take place before considering withdrawal of care due to neurological futility before this 3-day period if therapeutic hypothermia has been used. At the University of Arizona, we recently had a patient who remained comatose for 8 days after rewarming, and then abruptly awoke and is completely functional 6 months later. Such experiences are not rare.

Abbreviations and Acronyms

ACS = acute coronary syndrome(s)

ECG = electrocardiogram

MTH = mild therapeutic hypothermia (32°C to 34°C)

OHCA = out-of-hospital cardiac arrest

PCI = percutaneous coronary intervention

STEMI = ST-segment elevation myocardial infarction

VFCA = ventricular fibrillation cardiac arrest

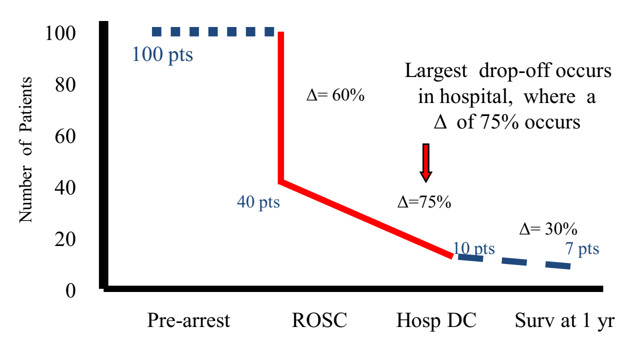

Figure 1. An Idealized Survival Curve After OHCA

The greatest drop-off in survival is not at the initial treatment in the field, but occurs in the hospital where 75% of those initially resuscitated die before hospital discharge (DC). Hosp = hospital; OHCA = out-of-hospital cardiac arrest; pts = patients; ROSC = return of spontaneous circulation; Surv = survival.

Coronary angiography and PCI after cardiac arrest. The other post-resuscitation therapy with real potential for affecting long-term survival after OHCA is coronary angiography/PCI. French investigators showed in the mid-1990s that the incidence of coronary disease among those resuscitated from OHCA was over 70%. They found that not only was coronary disease common in these cardiac arrest victims but, surprisingly, nearly 50% of those resuscitated had an occluded coronary vessel. They concluded, "acute coronary-artery occlusion is frequent in survivors of out-of-hospital cardiac arrest" (16). The assumption is that such acute coronary occlusions are the likely trigger of their cardiac arrest, suggesting a true cardiac etiology for their sudden death. In our Arizona SHARE (Save Hearts in Arizona Registry and Education) database of OHCA, we have found a noncardiac etiology in only 20% of adult out-of-hospital, nontraumatic cardiac arrests. The majority (60% to 80%) of adult OHCAs are "cardiac" in etiology, often triggered by acute coronary ischemia.

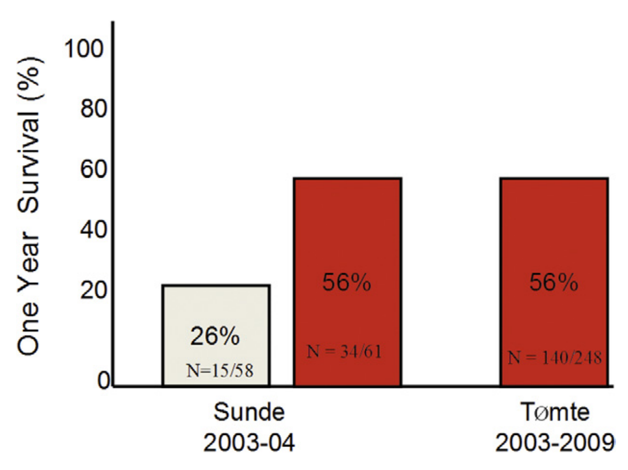

Figure 2. **1-Year Survival**

1-year survival improved from 26% to 56% in the first few years after instituting a formal standard operating procedure for post-resuscitation care, including emphasis on therapeutic hypothermia and early coronary angiography for possible percutaneous coronary intervention. Continued use of this new standard operating procedure resulted in a persistent 1-year survival rate of 56% for 6 consecutive years. Data from Sunde et al. (8) and Tømte et al. (9).

If most out-of-hospital "cardiac" arrests are precipitated by an acute ischemic event, particularly an acute coronary occlusion, then the strategy of emergent coronary angiography and potential PCI seems appropriate. When an acutely occluded coronary vessel is responsible for triggering cardiac arrest, not only does systemic circulation need to be restored, but also the culprit vessel needs to be reperfused if myocardial function and patient survival are to be optimally affected.

In nonarrested acute coronary syndrome (ACS) patients, emergent reperfusion is required if the vessel is acutely occluded, that is, for ST-segment elevation myocardial infarction (STEMI) patients. Most medical centers now engage in an emergent primary PCI approach for such patients, identifying them by acute ST-segment elevation on their electrocardiograms. Great effort and resources have been applied to provide STEMI patients a 90-min door-to-reperfusion time. ACS patients with ST-segment depression or T-wave inversions, but not ST-segment elevation, generally do not require emergent coronary angiography (unless medically refractory symptoms persist). An urgent (within 24 h of admission) rather than emergent time course for coronary angiography seems most optimal for this group of patients (17). However, these ACS guidelines, based on clinical symptoms and electrocardiographic findings, were formulated from randomized trials that excluded cardiac arrest patients. Indeed, Spaulding et al. (16) found that pre-arrest symptoms and post-resuscitation electrocardiographic findings are not as helpful in determining which post-resuscitated patients need emergent coronary angiography and intervention and which could wait 12 to 24 h for such studies. These French investigators concluded from their experience that "acute coronary-artery occlusion is frequent in survivors of out-of-hospital cardiac arrest and is predicted poorly by clinical and electrocardiographic findings . . . such as chest pain or ST-segment elevation" (16, p. 1629 and 1632). These investigators found that among resuscitated patients without ST-segment elevation, 11% had an acutely occluded coronary artery (16).

Who Should Have Emergent Coronary Angiography After Resuscitation From Cardiac Arrest?

Those with ST-segment elevation on their post-resuscitation ECG. What should be done if obvious ischemic ST-segment elevation is present on the electrocardiogram after resuscitation? There have been no randomized trials that included STEMI patients who suffered cardiac arrest. In fact, such patients were deliberately excluded from the large ST-segment elevation clinical trials due to concern over their higher risk for poor outcomes. The only data concerning the post–cardiac arrest patient with electrocardiographic ST-segment elevation consists of nonrandomized case series. These data now include 19 reports involving nearly 1,100 patients (16,18–35). Overall, 60% survived to hospital discharge. This is double the historical survival rate of 25% to 30%. The really good news is that 86% of these survivors had favorable neurological outcome, defined as a cerebral performance category of 1 or 2 (Table 2). These summary

Table 1. **2 Clinical Randomized Trials of MTH**

Trial/Author (Ref. #)	n	Temp Goal	Duration	Time to Temperature	Survival	Survival With Favorable Neurological Function
HACA trial (11)						
Normothermia	137	—	—	—	62/138 (45%)	54/138 (39%)
Hypothermia	136	33°C	24 h	8 h	81/137 (59%)*	75/137 (55%)*
Bernard et al. (12)						
Normothermia	34	—	—	—	11/34 (32%)	9/34 (26 %)
Hypothermia	43	33°C	12 h	2 h	21/43 (49%)	21/43 (49 %)*

Values are n/N (%). *$p < 0.05$ versus normothermic cohort.
HACA = Hypothermia After Cardiac Arrest; MTH = mild therapeutic hypothermia (32°C to 34°C).

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Table 2. 19 Clinical Reports of Coronary Angiography After Resuscitation From Cardiac Arrest

First Author Year (Ref. #)	Survival to DC	Survivors With Favorable Neurological Function
Kahn 1995 (18)	6/11	4/6
Spaulding 1997 (16)	32/84	30/32
Lin 1998 (19)	9/10	NA
Bulut 2000 (20)	4/10	NA
McCollough 2002 (21)	22/54	14/22
Borger van der Berg 2003 (22)	39/42	NA
Keelan 2003 (23)	11/15	9/11
Bendz 2004 (24)	29/40	NA
Quintero-Moran 2006 (25)	18/27	NA
Gorjup 2007 (26)	90/135	72/90
Garot 2007 (27)	102/186	88/102
Richling 2007 (28)	24/46	22/24
Markusohn 2007 (29)	19/25	17/19
Werling 2007 (30)	9/13	NA
Pleskot 2008 (31)	14/20	11/14
Hosmane 2009 (32)	63/98	58/63
Anyfantakis 2009 (33)	35/72	33/35
Reynolds 2009 (34)	52/96	NA
Lettieri 2009 (35)	77/99	67/77
Totals: N = 1,083*	655/1,083 (60%)	425/495 (86%)

Values are n/N or n/N (%). *Includes both those conscious and unconscious on arrival at the hospital.
DC = discharge; NA = not available.

data contain a wide variety of patients, including those who were conscious after resuscitation and those who were comatose, some after VFCA, and some after non-VFCA. The overall experience strongly suggests that any STEMI patient who suffers OHCA and is successfully resuscitated should be treated with emergent reperfusion, typically PCI.

Gorjup et al. (26) reported their experience with 2,393 consecutive STEMI patients, 135 (6%) of whom had cardiac arrest and were successfully resuscitated. Among those successfully resuscitated from OHCA, the overall neurologically intact survival-to–hospital discharge was 55%. Among these resuscitated STEMI patients, approximately one-third regained consciousness before urgent coronary angiography on admission. The other two-thirds remained in a coma at the time of cardiac catheterization. Those regaining consciousness before immediate invasive approach had the same hospital survival rate as those who did not suffer cardiac arrest with their STEMI (100% vs. 95%), whereas those who were comatose at the time of catheterization had a survival-to–hospital discharge rate of 51%, which is significantly less than for those conscious at time of catheterization (51% vs. 100%; $p < 0.01$). In comparison, the historical control survival rate for resuscitated victims, including both comatose and conscious patients, without the use of emergent coronary angiography and potential PCI is only 25% to 35% (2–6).

Garot et al. (27) published their experience with 186 STEMI patients resuscitated from OHCA. They found similar outcomes, with 54% surviving to hospital discharge and 86% of the survivors neurologically intact.

Hosmane et al. (32) were the first to report a large experience in the United States. Their results were nearly identical to the European experience. Sixty-four percent survived to hospital discharge and 92% of all survivors had favorable neurological function on discharge. These investigators found, as have others, that the following factors were associated with better outcome: a shorter resuscitation time, being awake after cardiac arrest at the time of coronary angiography, and being younger.

Immediate post-resuscitation neurological function, in other words, if the patient is conscious or comatose, should not be the deciding factor in whether to perform emergent coronary angiography and potential coronary intervention. Excellent long-term neurologically favorable outcomes can be achieved even in those comatose at the time of cardiac catheterization.

Such evidence led the American Heart Association and International Liaison Committee on Resuscitation in their 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment recommendations to recommend: "In OHCA patients with STEMI or new LBBB on ECG after ROSC, early angiography and PPCI should be considered. Out-of-hospital cardiac arrest patients are often initially comatose but this should not be a contraindication to consider immediate angiography and PCI. It may be reasonable to include cardiac catheterization in a standardized post-cardiac-arrest protocol as part of an overall strategy to improve neurologically intact survival in this patient group" (36, p. S436).

Those without ST-segment elevation on the post-resuscitation ECG. It appears that the optimal care of the STEMI patient resuscitated from cardiac arrest includes emergent coronary angiography—but, what if there is no ST-segment elevation on the post-resuscitation electrocardiogram? Should such patients also undergo emergent cardiac catheterization and possibly PCI? Experience with nonarrested ACS patients suggests that those without electrocardiographic ST-segment elevation are unlikely to benefit from emergent coronary reperfusion (17). However, as noted, the electrocardiogram after successful resuscitation is not as helpful in identifying acute coronary occlusion. Several case series of post-resuscitation patients undergoing emergent coronary angiography have included those without ST-segment elevation.

Anyfantakis et al. (33) studied a series of 72 consecutive OHCA survivors who underwent urgent cardiac catheterization without regard for the length of time it took to resuscitate, their precedent clinical complaints, or their post-resuscitation electrocardiographic findings. Similar to the findings of Spaulding et al. (16), about one-third of their patients had ST-segment elevation on their post-resuscitation electrocardiogram, whereas two-thirds did not. Thirty-eight percent had angiographic findings compatible with an ACS, either having acute occlusion or irregular and unstable lesions suggestive of ruptured plaque with thrombus. Within this subgroup, nearly one-half had an acute occlusion. They found that ST-segment elevation on the 12-lead post-resuscitation electrocardiogram (ECG) had a positive predictive value of 95% for the identification of significant angiographic coronary disease, but its negative predictive value was only 44%. This suggests that the lack of ST-segment elevation on the post-resuscitation 12-lead ECG is not a reliable predictor for the absence of acute coronary disease.

Radsel et al. (37) from Slovenia studied 335 consecutive patients resuscitated from OHCA. Fifty-three percent had ST-segment elevation, whereas 47% had no ST-segment elevation on their post-resuscitation ECG. Approximately one-third of those without ST-segment elevation had urgent coronary angiography, based on clinical suspicions that acute coronary events precipitated their cardiac arrests. Patients with obvious nonischemic causes for cardiac arrest and those judged to have no realistic hope for neurologic recovery did not undergo coronary angiography. Obstructive coronary lesions considered acute were found in 26% of those without ST-segment elevation. They found that one-third of those with acute coronary lesions but no ST-segment elevation on their post-arrest ECG had an acute thrombotic occlusion on angiography. They noted that even in the absence of ST-segment elevation, an acute culprit lesion is present in 25% of patients (Fig. 3). They concluded that urgent coronary angiography and PCI are reasonable and successful regardless of the post-resuscitation ECG findings.

Dumas et al. (38), reporting for the PROCAT (Parisian Region Out of-Hospital Cardiac Arrest) registry, on 435 cardiac arrests taken directly to coronary angiography status

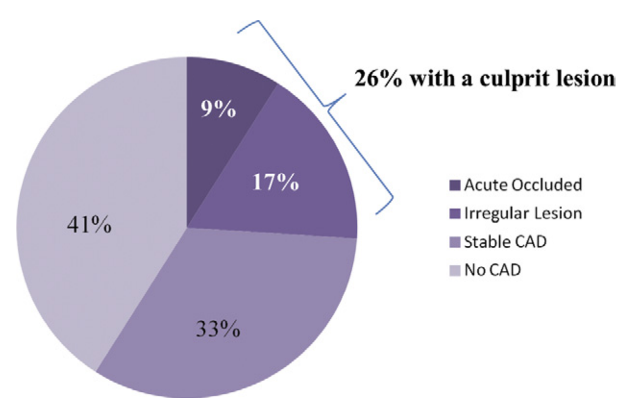

Figure 3. Coronary Angiography Results

Coronary angiographic results showing that 1 of every 4 resuscitated patients without ST-segment elevation has an acute culprit lesion found at early coronary angiography. Data from Radsel et al. (37). CAD = coronary artery disease.

after resuscitation, found no differences in age, initial rhythm, or other common risk factors between those with ST-segment elevation (n = 134) or those without ST-segment elevation (n = 301). Those without ST-segment elevation had a variety of ECG findings, including ST-segment depression (29%), conduction abnormalities (20%), and nonspecific changes (9%), with some even being normal (11%). Significant coronary lesions were found in 58% of those without ST-segment elevation, and nearly one-half of these had PCI (78 of 176). Hospital survival was significantly higher in patients with successful PCI versus those having no or unsuccessful PCI. This was true for patients with and without ST-segment elevation. Multivariable analysis showed successful PCI to be an independent predictor of good outcome, regardless of the initial post–cardiac arrest electrocardiographic pattern. These investigators concluded that immediate PCI (combined with therapeutic hypothermia) results in improved survival for OHCA patients with no obvious noncardiac cause, whether or not their electrocardiogram manifests ST-segment elevation.

An additional report from France by Cronier et al. (39) confirms the idea that routine coronary angiography with potential PCI favorably alters the prognosis of resuscitated patients after OHCA, regardless of the presence or absence of ST-segment elevation. In 111 consecutive cases of resuscitated ventricular fibrillation patients, less than one-half had ST-segment elevation on their post-resuscitation ECG. No significant differences in outcomes were found between those with and without ST-segment elevation.

A summary of the available data comparing outcomes after acute coronary angiography post–cardiac arrest among patients with and without ST-segment elevation is seen in Figure 4. Survival was 49% in those with ST-segment elevation after emergent coronary angiography and PCI and 45% in those without ST-segment elevation ($p = 0.72$). Likewise, there was no difference in intact neurological function among survivors between those with and those without ST-segment elevation (79% vs. 82%; $p = 0.66$).

The new 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment recommendations state: "It is reasonable to perform early angiography and primary percutaneous coronary intervention in selected patients despite the absence of ST-segment elevation on the ECG or prior clinical findings, such as chest pain, if coronary ischemia is considered the likely cause on clinical grounds" (36, p. S436).

The ultimate consideration for the cardiac interventionalist is this: What proportion of patients having an acutely occluded coronary, but no ST-segment elevation after cardiac arrest, is sufficient to proceed with coronary angiography for all those successfully resuscitated? Is finding 1 acute culprit of every 3 to 4 patients taken emergently to the catheterization suite enough to submit all to emergent

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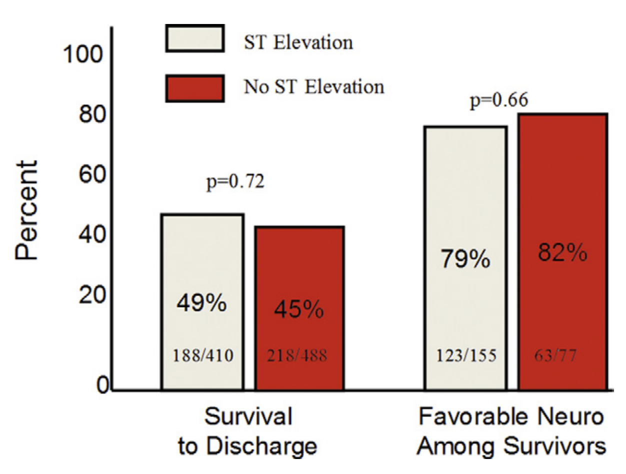

Figure 4. Differences in Survival

No differences in survival-to-discharge or favorable neurological function among survivors were seen between those with or without ST-segment elevation on their post-resuscitation electrocardiograms. Data from Radsel et al. (37), Dumas et al. (38), Cronier et al. (39), and Mooney et al. (49). Neuro = neurological function.

coronary angiography? The "number needed to treat" with emergent coronary angiography after cardiac arrest to find an acute culprit lesion needing emergent revascularization among those without ST-segment elevation is, in fact, just 4 patients. These data strongly suggest that anyone successfully resuscitated from out-of-hospital arrest thought to be cardiac in etiology should undergo emergent coronary angiography, regardless of their post-resuscitation ECG findings.

Acute coronary angiography after resuscitation from cardiac arrest is not just about finding atherosclerotic disease. We published a small series of cases from our experience at the University of Arizona, Sarver Heart Center where no ST-segment elevation was present on the post–cardiac arrest ECG, but important treatment-altering information was found at cardiac catheterization (40). None of the 5 patients had evidence of ST-segment elevation on the ECG after resuscitation. One patient had no coronary atherosclerosis, but rather a significant congenital coronary anomaly, with an absent left main coronary artery. The left anterior descending and circumflex coronary arteries were filled by a small right-sided acute marginal vessel.

When Should Post-Resuscitation Coronary Angiography Be Performed?

There are no data to definitively answer this question. The studies on post-resuscitation use of coronary angiography suggest it be performed "immediately, urgently, or emergently," but time intervals are rarely provided. According to the fundamental principles of myocardial ischemia and reperfusion (41), if an acutely occluded coronary was the trigger for cardiac arrest, timely reperfusion should preserve long-term myocardial function better than late reperfusion would. Hence, in those with ST-segment elevation, emergent catheterization has been the rule among the centers using post-resuscitation coronary angiography; but, as noted, a similar argument can be made for those without ST-segment elevation because the predictive value of having no ST-segment elevation after resuscitation is poor for ruling out acute coronary occlusion.

Optimal Post-Resuscitation Care Combines MTH With Coronary Angiography and PCI

What if MTH and emergent coronary angiography are simultaneously provided for the comatose post-resuscitation patient? Is this optimal therapy or wasted effort? Can such even be done simultaneously or must 1 therapy wait on the other? Simultaneous treatment is feasible. There are now over 1,500 patients reported in the literature who have received both hypothermia and emergent coronary angiography after resuscitation from cardiac arrest (9,37–39,42–50). Table 3 shows the outcomes from 13 reports of OHCA patients who were successfully resuscitated, but remained unconscious. Each received therapeutic hypothermia combined with emergent coronary angiography, and PCI where indicated. Overall survival was 54%, with 88% of survivors having good neurological outcomes. These results do not look much different from the earlier experience with early cardiac catheterization alone. Why did the combination of therapeutic hypothermia and coronary angiography not result in better outcomes than angiography alone? The answer is mainly that the 2 populations studied are dramatically different. About 35% of the patients undergoing

Table 3. 13 Clinical Reports of Combined MTH and Coronary Angiography/PCI After Cardiac Arrest

First Author Year (Ref. #)	Survival to DC	Survivors With Favorable Neurological Function
Hovdenes 2007 (42)	41/50	34/41
Knafelj 2007 (43)	30/40	22/30
Wolfrum 2008 (44)	12/16	11/12
Schefold 2009 (46)	NA	19/31
Reynolds 2009 (34)	52/96	NA
Batista 2010 (47)	8/20	6/8
Dumas 2010 (38)	171/435	160/171
Stub 2011 (48)	52/81	46/52
Laish-Farkash 2011 (50)	69/110	59/69
Tømte 2011 (9)	140/252	132/140
Radsel 2011 (37)	154/212	128/154
Mooney 2011 (49)	78/140	72/78
Cronier 2011 (39)	60/111	54/60
Totals: N = 1,563	867/1,563 (55%)	743/846 (88%)

Values are n/N or n/N (%).
NA = not available; PCI = percutaneous coronary intervention.

emergent catheterization without hypothermia were conscious at the time of hospital admission. Only patients who remain comatose after arrest are treated with hypothermia. This post-resuscitation comatose subgroup is known to have a more ominous prognosis than those who are awake after resuscitation on delivery to the hospital (26). It is not surprising, therefore, that the overall survival among those comatose and treated with hypothermia and angiography was slightly less than for the group that consisted of both conscious and unconscious patients (54% vs. 60%; $p = 0.001$). It is remarkable that among the 54% who survived having been initially comatose, 88% were neurologically intact, a proportion not different from the group with both conscious and unconscious patients (88% vs. 86%; $p = 0.33$). The combination of mild hypothermia and emergent cardiac catheterization for post–cardiac arrest patients remaining comatose after resuscitation from cardiac arrest should be the standard of care, not the exception.

In 2011 alone, 6 reports combining therapeutic hypothermia and emergent coronary angiography were published (9,37–39,48–50).

Investigators from Ljubljana, Slovenia, reported their experience with 158 consecutive patients with STEMI and cardiac arrest (37). Eighty-eight percent had emergent coronary angiography and 85% received therapeutic hypothermia. Overall survival-to–hospital discharge was 70%. Intact neurological function among survivors was seen in 100% of those who had regained consciousness immediately after resuscitation, and 63% in those who remained comatose on hospital admission.

In one of the largest series reported to date, investigators from Paris showed that STEMI and non-STEMI patients who suffered cardiac arrest, and were then treated with therapeutic hypothermia and a successful PCI, had significantly better survival rates than those patients who had no or a failed PCI (54% vs. 31%, $p < 0.001$) (38). Both MTH and emergent coronary angiography/PCI were important in achieving optimal long-term survival with favorable neurological function among survivors.

A second group of investigators from France noted a 54% survival-to-discharge rate with 90% of survivors being neurologically intact among 111 consecutively treated resuscitated victims of out-of-hospital VFCA (39).

Other investigators from Australia found among 125 patients, comparing a historic control period (2002 to 2003) with a more contemporary period (2007 to 2009), that the combination of therapeutic hypothermia and early coronary angiography resulted in a significantly better survival (39% vs. 64%; $p = 0.01$), as well as favorable neurological recovery among survivors (52% vs. 88%; $p = 0.01$) (48).

Researchers from Minneapolis published their experience in providing therapeutic hypothermia and emergent coronary angiography for resuscitated STEMI patients suffering OHCA (49). Sixty-eight STEMI patients received such therapy with 65% surviving to discharge. Among the survivors, 93% had favorable neurological function. Of interest, a majority of their patients were transferred from outlying hospitals.

Finally, researchers from Israel found in 110 consecutive unconscious patients who were resuscitated from cardiac arrest and then treated with hypothermia and emergent coronary angiography an overall survival rate of 63%, with 86% of survivors having favorable neurological recovery (50).

The 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment recommendations state: "Therapeutic hypothermia is recommended in combination with primary PCI, and should be started as early as possible, preferably before initiation of PCI" (36, p. S436). The American Heart Association's 2010 Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care suggest that "angiography and/or PCI need not preclude or delay other therapeutic strategies including therapeutic hypothermia" (Class IIa, Level of Evidence: B) (51, p. S798).

University of Arizona, Sarver Heart Center Approach to the Post-Resuscitation Patient

Every patient fortunate enough to be successfully resuscitated from OHCA and brought to our hospitals is considered for aggressive post-arrest care. If the etiology of arrest is clearly not cardiac (known trauma, known respiratory or choking arrest) or if the patient was found to be in arrest for an extended time before assistance was rendered, coronary angiography is not performed. If such a patient is unconscious on arrival at the hospital, we would induce mild hypothermia for 24 h, but would carefully relay realistic decreased expectations while acknowledging that cooling offers the best opportunity for maximal central nervous system recovery. If a cardiac etiology is more likely, we will begin cooling any who are comatose, while simultaneously calling the emergent STEMI response team for immediate coronary angiography, regardless of the presence or absence of ST-segment elevation on the post-resuscitation ECG. We attempt to meet the same goal of a 90-min door-to-reperfusion time for all post-resuscitation patients as we have for our STEMI patients. Clinical judgment is important and, certainly, sometimes the appropriate decision is not to pursue aggressive post-resuscitation care. An echocardiographic quick look for segmental wall motion abnormalities can be accomplished in just a few minutes, but rarely is it known how long such wall motion abnormalities have been present. The global hypokinesis of post-resuscitation myocardial stunning (52) can also obscure the echocardiographic findings and conclusions. For these reasons, we do not routinely do emergent echocardiography on our post-resuscitation patients. Factors, such as hemodynamic instability, initial rhythm (VF or non-VF), "downtime," lengthy and difficult resuscitation, known comorbid conditions, and age are all considered, but none are absolute contraindications. We aggressively treat cardiogenic shock with medications or devices as needed. We do not take patients to the catheterization suite with ongoing chest compressions, from either the field or the Emergency Department, as their long-term prognosis is dismal (53). On completion of the emergent coronary angiogram, we continue mild hypothermia for 24 h, even if PCI is not performed. Finally, we do not attempt to neurologically prognosticate such patients until at least 72 h after rewarming. We believe this approach is compatible with the current data and provides each individual resuscitated patient their best opportunity for long-term neurologically intact survival.

Conclusions

Cardiologists, and particularly interventional cardiologists, must assume an increasing role in the care of patients suffering OHCA. Post-resuscitation care is the key to improving the proportion that not only survive long term, but also survive with favorable neurological function. The role of the interventional cardiologist can be crucial in providing this optimal post–cardiac arrest care. The interventional cardiologist needs to become a champion for those successfully resuscitated by ensuring that all patients receive their best chance for long-term recovery with preserved myocardial and central nervous system function. The 2 most important aspects of post-resuscitation care in this regard are therapeutic hypothermia and early coronary angiography with potential PCI.

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